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(54) Remote testing of a communications line

(57) Apparatus and method for remotely measuring characteristics of a communications line (4) wherein a receiver unit (8) is connected a remote end of line (4) between conductors (10,12) of the line (4) and a sender unit (6) is connected to the other end of line (4) between conductors (10,12). On depressing a function key or button on receiver unit (8) representative of a characteristic of line (4) to be measured, the receiver unit has a signal generator which transmits a unique signal or code identifying the characteristic to the sender unit (6) along line (4). The sender unit (6) detects the unique signal and passes the signal to a microprocessor which controls switching means to connect the corresponding circuitry between conductors (10,12), based on the unique signal or code, to allow the characteristic to be measured.

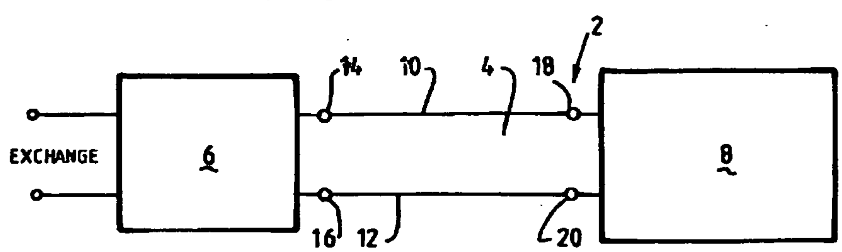

FIG. 1.

EP 0 880 258 A2

Description

This invention relates to a method of, and apparatus for, remotely testing a communications line, and more particularly to a method of, and apparatus for, testing a communications line to ascertain its suitability, under high frequency transmissions, for transmitting data at high bit rates.

There is a need to conduct tests and perform measurements on a communications line, including a telephone line, such as the characteristics of line loss, noise and resistance. This is so that the line's suitability for high frequency digital systems like pair gain, basic rate ISDN and Internet connections can be established. Generally, at high frequencies, the loss in signal magnitude is much higher than at low frequencies. For example, at 100kHz, the line loss can be as much as 45 Db for a small pair gain system. This is primarily due to the increase in inductance on the line as frequency increases. A Plain Ordinary Telephone Service (POTs) line can often tolerate adverse transmission conditions caused by bridged taps, split pairs, poor joints and low insulation resistance. However, these conditions seriously affect the operation of high frequency digital systems and therefore must be identified.

Previously there has been no known method of measuring line loss and performing other measurements remotely from the receiving end of a communications line. One arrangement has consisted in setting up identical measuring instruments one at each end of the line under test. Each instrument is very expensive and furthermore, switching of the instruments between different functions to be measured has to be performed manually. There is also known Australian Patent No. 604878, in the name of the applicant, which discloses a system for remotely disconnecting and short-circuiting a pair of conductors. However, the system disclosed therein does not facilitate remotely switching between a plurality of measurement functions such that the required circuit elements to enable such measurement are connected to the communications line at both ends of the line, that is, the sender end and the receiver end.

The present invention provides for an apparatus for remotely measuring characteristics of a communications line including:

receiver means for connection to a remote end of the communications line;
sender means for connection to the other end of the communications line;
said receiver means generating a signal in response to a selection of one of a plurality of characteristics of said line to be measured;
said signal uniquely representing said selected characteristic;
said signal being transmitted along the communications line toward the sender means;
said sender means having detection means for detecting said signal, and switching means;
such that on detection of said signal and, on the basis of the unique representation of the signal, the switching means is controlled so as to connect predetermined circuitry across the line at said other end and at said remote end to enable a selected characteristic of the line to be measured.

Preferably, said signal is generated by signal generation means and is assigned a unique code, such as a sequence of pulses representing characteristics to be measured.

Preferably, when the signal is detected by said detection means, said signal is converted into a digital code and forwarded to a processing means, such as a microprocessor, which controls the switching means on the basis of the digital code representing the signal. Preferably, said switching means is in the form of a set of relays.

The present invention also provides for a method of remotely measuring characteristics of a communications line, including the steps of:

connecting receiver means to a remote end of the communications line;
connecting sender means to the other end of the communications line;
causing the receiver means to generate a signal in response to a selection of one of a plurality of characteristics of said line to be measured, said signal uniquely representing said selected characteristic;
transmitting said signal along the communications line toward the sender means;
detecting said signal through the sender means and, on the basis of the unique representation of the signal, controlling switching means to connect predetermined circuitry across the line at said other end and at said remote end to enable a selected characteristic of the line to be measured.

The invention will now be described in a preferred embodiment, by way of example only, with reference to the accompanying drawings wherein:

Figure 1 is a block diagram of a communications line having receiver unit and sender unit connected to each end of the line;

Figure 2 is a front view of the receiver unit panel;

Figure 3 is a block diagram showing an example of the operation of the sender unit in response to a signal being generated at the receiver unit;

Figure 4 is a block diagram of the internal circuitry of the receiver unit;

Figure 5 is a block diagram of circuitry required for

a 3kHz loss measurement;

Figure 6 is a block diagram of circuitry required for an 820 Hz loss measurement;

Figure 7 is a block diagram of circuitry required for a 100kHz loss measurement;

Figure 8 is a block diagram of circuitry required to perform noise measurements on the communications line;

Figure 9 is a block disgram of circuitry required to detect split pairs of a communications line;

Figure 10 is a block diagram of a communications line set up to measure insulation resistance on the line;

Figure 11 is a block diagram of a communications line set up to measure loop resistance on the line;

Figure 12 is a block diagram of a communications line set up to measure DC voltage on the line;

Figure 13 shows circuitry in the sender unit and a probe unit at the other end of a communications line to identify pairs of conductors of the line; and

Figure 14 is a block diagram of an exchange through connection.

Figure 1 shows apparatus 2 for performing test measurements on a communications line 4 having conductors 10 and 12. At the exchange side of the line 4, sender means in the form of a sender unit 6 is connected between conductors 10 and 12 at terminals 14 and 16 and at the receiver end of line 4 is connected receiver means in the form of a receiver unit 8 at terminals 18 and 20. Alternatively the sender unit 6 can be connected across line 4 at a pillar or pit. Receiver unit 8 is used to display test results on line 4 and to remotely control the sender unit 4. Additionally a probe unit is used for identification of a pair of conductors of the line, to be described later. The apparatus 2 is able to connect and disconnect a short-circuit (strap). While the line 4 is short-circuited, the apparatus 2 may decode signals transmitted from receiver unit 8 to sender unit 6.

Apparatus 2 is able to perform a number of tests or measurements including the characteristics of line loss measurements at various frequencies, noise on the line 4, insulation resistance, loop resistance and DC voltage, all remotely from receiver unit 8. It also is capable of performing tests for split pairs of conductors using capacitance unbalance and pair identification and enables connection or disconnection of the conductors from the exchange. The pair identification and remote connection and disconnection is described in Australian Patent No. 604878.

In Figure 2, there is shown a receiver unit 8 having function keys or buttons 22. The user may depress a particular key and the required function is switched into the line 4. The measured value is then displayed on the multi-character alpha-numeric LCD 24.

Figure 3 shows an example of the apparatus 2 in operation. With the sender unit 6 and receiver unit 8 connected at respective ends of communications line 4, the user at the receiver end may depress any required button 22 to perform a test on the line 4. In depressing a button 22, a signal is sent to a signal generator 26 which emits a coded series of pulses at 171 Hz, each coded series of pulses representing a signal for each test function. For example, to test for line loss at 100kHz, the signal may be represented by a sequence of two pulses, followed by no pulse and then one more pulse. This signal is transmitted over line 4 to sender unit 6 whereupon the signal is filtered by filter 28 and detected by detector means 30. The sequence is then converted or translated into the digital code 1101 and transmitted to processor means in the form of microprocessor 32 which directs or switches switching means 34 in the form of a bank of relays 34, such that the appropriate relay allows predetermined circuitry based on the code, to be connected between conductors 10 and 12 of line 4. In this example, code 1101 is for the 100 Khz oscillator. Therefore its relay is closed and the 100 Khz oscillator in sender section 36 is connected between the conductors 10 and 12.

It is to be noted that any other form of switching means may be used, such as those fabricated from semiconductors as is well known in the art.

Connection to the conductors 10 and 12 of various circuit elements for each test function will now be described with reference to Figure 4.

In Figure 5 there is shown a circuit in which line 4 is being measured to determine a value for a 3 Khz loss. When a button 22 corresponding to a 3kHz loss measurement is depressed, the code is sent to the sender unit 6, as described previously, and the circuitry at section 36 is connected between the conductors 10, 12. Specifically, a 3 Khz oscillator 38 and a impedance 40 is connected, the impedance 40 being 600Ω or TN 12. The exchange side of the line 4 is "busied" by the insertion of a 990Ω resistor so that incoming calls are not connected through to line 4. In operation a 3 Khz, -10dBm sinusoidal signal is connected to the line at the sender and the receiver unit 8 measures the line loss. A 600Ω resistor or TN12 termination 42 is inserted between conductors 10 and 12 at the receiver unit 8. The sinusoidal signal is then switched by relay 48 through to amplifier 50, filter 44 and rectifier 52 before being averaged and passed onto analogue to digital converter (ADC) 56. Therefore, voltmeter 46 measures the signal magnitude and is converted to a decibel reading and output to LCD 24 of the receiver unit 8 so as to give a loss reading.

Similarly in Figure 6, to determine the loss on line 4 at 820Hz, the appropriate button 22 is pressed. At the sender unit 6, a 820Hz oscillator 60 and 600Ω or TN12 impedance 58 is connected between the conductors 10 and 12. An 820Hz, -10dBm sinusoidal signal is transmitted down the line 4 toward receiver unit 8 and the line loss measured. The signal is switched by relay 62, then amplified, filtered, rectified and averaged before passing on to ADC 56 for conversion into decibels from voltmeter 68.

In Figure 7 is shown a circuit arrangement for measuring loss on line 4 at 100kHz. Again a corresponding button 22 is pressed, a signal generated by generator 26 and coded and transmitted to sender unit 6. A 100kHz oscillator 70 and complex impedance 72 having a value of (120-j23) Ω is connected in the line 4 based on the assigned code. A 100kHz, 0 Dbm sinusoidal signal is sent down line 4. To minimize reflections on line 4 a matched impedance 74 having the same magnitude of impedance 72 is connected between conductors 10 and 12. This is after the signal has passed through relay 76, amplifier 78, filter 80, rectifier 82 and averager 54. The signal is then forwarded to ADC 56 after being read by voltmeter 84 and then converted to decibels to be read on LCD 24 as a loss at 100kHz.

To measure the amount of noise on line 4, a 600Ω resistor 86 is connected between conductors 10 and 12 when the appropriate button is depressed on the receiver unit 8, as shown in Figure 8. A corresponding 600Ω resistor 88 is connected on the receiver side of line 4. The signal is switched through relay 98 before being amplified by gain amplifier 100. A 3 Khz filter 102 is applied to the signal resulting in a 3 Khz flat noise signal from which a measurement is taken after it is applied to a peak detector 104 and buffered. Voltmeters 90, 92 and 94 measure the received noise signal between the conductors 10 and 12 and between each conductor and ground. The readings from the voltmeters is then converted to decibels and applied to ADC 56 to be read out on LCD 24.

To detect split pairs, capacitive unbalance is measured on line 4. The line 4 is effectively open-circuited at the sender unit 6 as shown in Figure 9. The receiver unit 8 measures the capacitive unbalance of the conductors 10, 12 to ground through voltmeter 118. Relay 108 is closed to enable the receiver circuitry, wherein a 3 Khz oscillator 110 is fed to each input of amplifier 112 through appropriate impedances 114 and 116. The output of amplifier 112 is passed through filter 44 and then fed to the ADC 56 via rectifier 52 and averager 54. The LCD readout 24 displays the measured value.

To measure the insulation resistance on line 4, the sender unit 6 is connected to line 4 so that it is in the open-circuit condition as shown in Figure 10. Generally, insulation resistance is measured at high voltage, typically using a 500VDC source, as many of the digital systems mentioned previously are line powered by voltages up to 320VDC. Nothing is connected between the terminals in accordance with the specific code received by the sender in response to the IR button being depressed on the receiver unit 8. In the receiver unit, the insulation resistance is measured between the conductors 10 and 12 and between each conductor and ground via ohm meters 124, 126 and 128. The signals are then amplified by amplifier 122 and a digital readout of the measured values is shown on LCD 24. Each test performed by the receiver unit 8 is continued for about 20 seconds so as to allow enough time for weak insulation to fail. The line 4 is then discharged on completion of the test

Figure 11 shows the apparatus set up to measure loop resistance on line 4. At the sender unit 6 the appropriate code is set to operate relay 134 such that the conductors 10 and 12 are short-circuited and therefore the line 4 is looped at 130. The loop resistance is measured by ohmmeter 132 and the signal amplified by amplifier 122 before being output to the LCD 24. In this loop mode, the receiver unit 8 may have terminals to facilitate the connection of external test instruments such as Pulse Echo Testers (PETs), Direct Reading Bridges and Multimeters. This enables calibration of the PETs and tests for finding bridge fault locations.

Furthermore, while the line 4 is short-circuited at the sender end, the sender unit 6 can still decode or detect the unique control signal transmitted by signal generator 26, which is representative of another characteristic of the line 4 to be measured. It does this by use of a current transformer which receives the signal whilst in this short-circuit mode of operation.

To measure DC voltage on line 4, the line is opened or isolated from the exchange and all sender unit circuitry, that is, it is put in an open-circuit condition. Voltages between the conductors 10 and 12, and between each conductor and ground are measured by voltmeters 136, 138 and 140, referring to Figure 12. The voltage signals are applied through relay 142 to gain amplifier 144 and full-wave rectifier 146, before being converted to digital form and read out on LCD 24. External instruments can also be connected to terminals on receiver unit 8.

Pair identification may be undertaken on telephone lines for the purpose of locating a fault or for installation of a telephone to be connected between a pair of lines. A warble tone oscillator 148 having a frequency between 2 and 3kHz is connected at the sender unit between the pair of conductors to be identified, as shown in Figure 13. A source impedance 150 of 600 ohms is also connected between the pair of conductors 10 and 12. The tone is sent down the line 4 and, at the remote end, a probe unit 152 is used to detect the tone which is converted to an audio output. The audio output indicates to the user that the correct pair of conductors is identified as having the loudest signal and the area of no signal, or null, is located midway between the conductors. The warble oscillator may be connected between the conductors either at the sender unit 6 or

from the receiver unit 8 remotely. The frequency of the warble tone is adjustable so that two or three senders can be distinguished.

With reference to Figure 14, the conductors 10 and 12 are connected directly to the exchange and there is no 990 ohm resistor. The connection is again controlled by receiver unit 8 generating a suitable code to the sender unit 6 so that the conductors are directly connected to the exchange. The receiver unit 8 then is able to measure DC line voltages between the conductors 10 and 12 and between each conductor and ground through voltmeters 154, 156 and 158.

The sender unit 6, receiver unit 8 and probe unit 152 are each powered by 9V alkaline batteries. The sender unit can also be powered from the 48V to 52V DC exchange battery via standard MDF battery jacks. Power saving measures are employed to maximise the battery life. The receiver unit 8 switches off after a period of inactivity to conserve power.

Claims

1. Apparatus for remotely measuring characteristics of a communications line including:

   receiver means for connection to a remote end of the communications line;
   sender means for connection to the other end of the communications line;
   said receiver means generating a signal in response to a selection of one of a plurality of characteristics of said line to be measured;
   said signal uniquely representing said selected characteristic;
   said signal being transmitted along the communications line toward the sender means;
   said sender means having detection means for detecting said signal, and switching means;
   such that on detection of said signal and, on the basis of the unique representation of the signal, the switching means is controlled so as to connect predetermined circuitry across the line at said other end and at said remote end to enable a selected characteristic of the line to be measured.

2. Apparatus according to claim 1 wherein said signal is generated by signal generation means and is assigned a unique code such that said unique code is representative of a characteristic of the line to be measured.

3. Apparatus according to claim 2 wherein said signal assigned a unique code is represented by a sequence of pulses.

4. Apparatus according to any one of the previous claims wherein, on detection by said detection means of said signal, said signal is converted into a digital code.

5. Apparatus according to claim 4, further including processor means for receiving and processing said digital code representing said signal.

6. Apparatus according to claim 5 wherein said switching means is controlled by said processor means to connect said predetermined circuitry on the basis of the particular code received and processed by said processor means.

7. Apparatus according to any one of the previous claims wherein said selection of one of a plurality of characteristics is made by depressing a respective button on said receiver means.

8. Apparatus according to any one of the previous claims wherein said signal is a low frequency signal.

9. A method of remotely measuring characteristics of a communications line, including the steps of:

   connecting receiver means to a remote end of the communications line;
   connecting sender means to the other end of the communications line;
   causing the receiver means to generate a signal in response to a selection of one of a plurality of characteristics of said line to be measured, said signal uniquely representing said selected characteristic;
   transmitting said signal along the communications line toward the sender means;
   detecting said signal through the sender means and, on the basis of the unique representation of the signal, controlling switching means to connect predetermined circuitry across the line at said other end and at said remote end to enable a selected characteristic of the line to be measured.

10. A method according to claim 9, further including the step of assigning a unique code to said signal after being generated at said receiver means such that said unique code is representative of a characteristic of the line to be measured.

11. A method according to claim 10, further including representing said unique code as a sequence of pulses.

12. A method according to any one of claims 9 to 11 wherein said detecting step is conducted by detection means forming part of the sender means.

13. A method according to claim 12 wherein following the detecting step, said signal is converted into a digital code.

14. A method according to claim 13 wherein the controlling step is conducted by processor means, said processor means receiving and processing the digital code representing said signal.

15. A method according to claim 14 wherein the switching means is controlled by said processor mess to connect said predetermined circuitry on the basis of the digital code received and processed by said processor means.

16. A method according to any one of claims 9 to 15 further including depressing a respective button on said receiver means to enable said selection of one of a plurality of characteristics.

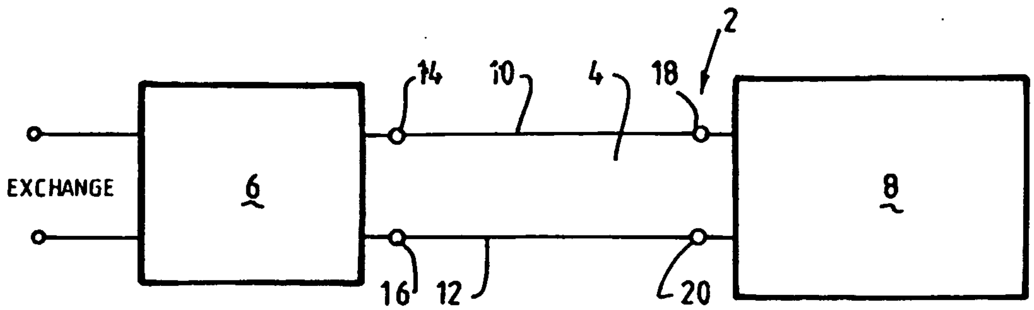

FIG. 1.

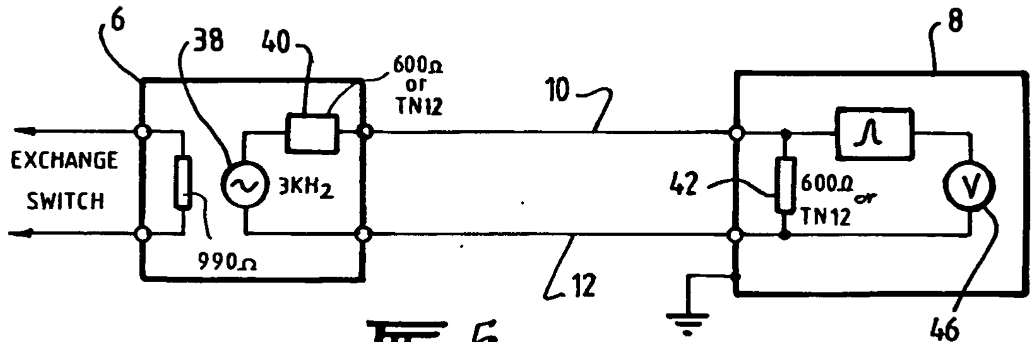

FIG. 5.

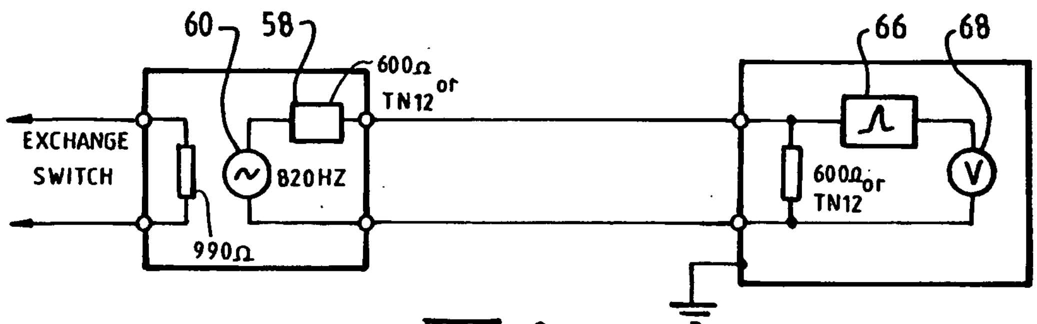

FIG. 6.

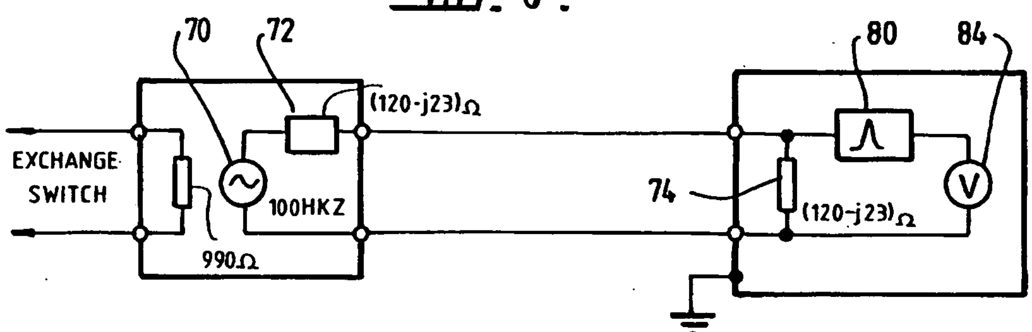

FIG. 7.

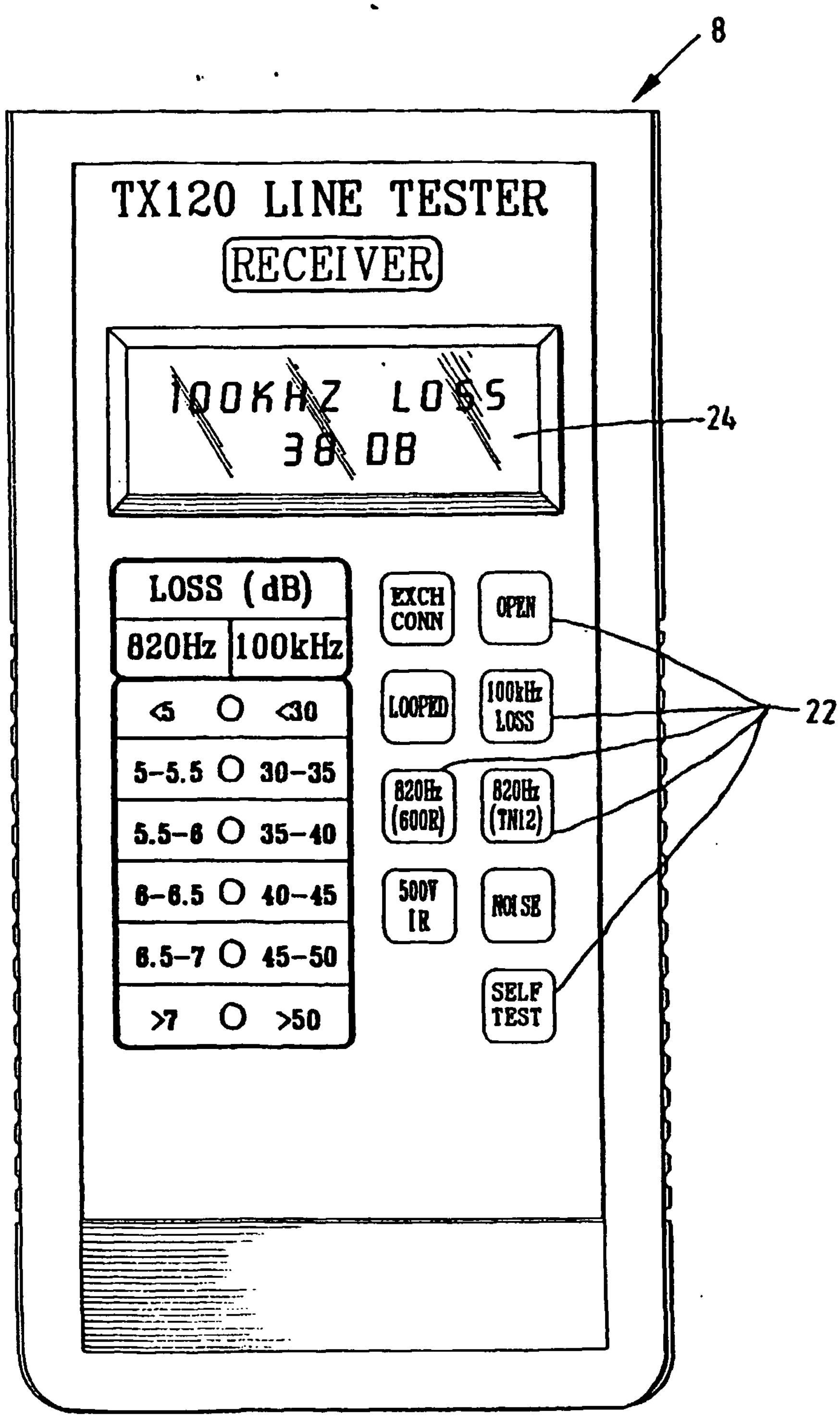
8
TX120 LINE TESTER
RECEIVER
100KHZ LOSS
38 DB
24
LOSS (dB)
820Hz
100kHz
<5
<30
5-5.5
30-35
5.5-6
35-40
6-6.5
40-45
6.5-7
45-50
>7
>50
EXCH CONN
OPEN
LOOPED
100kHz LOSS
820Hz (600R)
820Hz (TN12)
500V IR
NOISE
SELF TEST
22

FIG. 2.

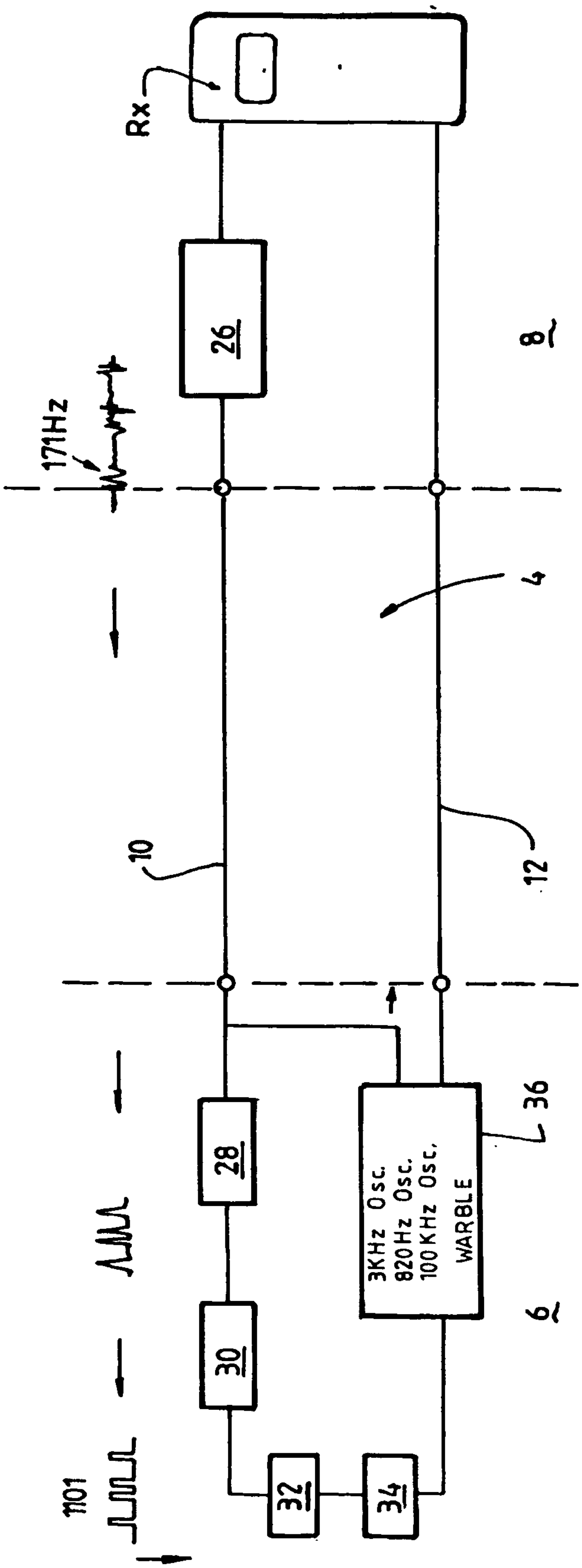
Rx
26
171Hz
8
4
10
12
28
30
32
34
36
6
3KHz Osc.
820Hz Osc.
100KHz Osc.
WARBLE
1101

FIG. 3.

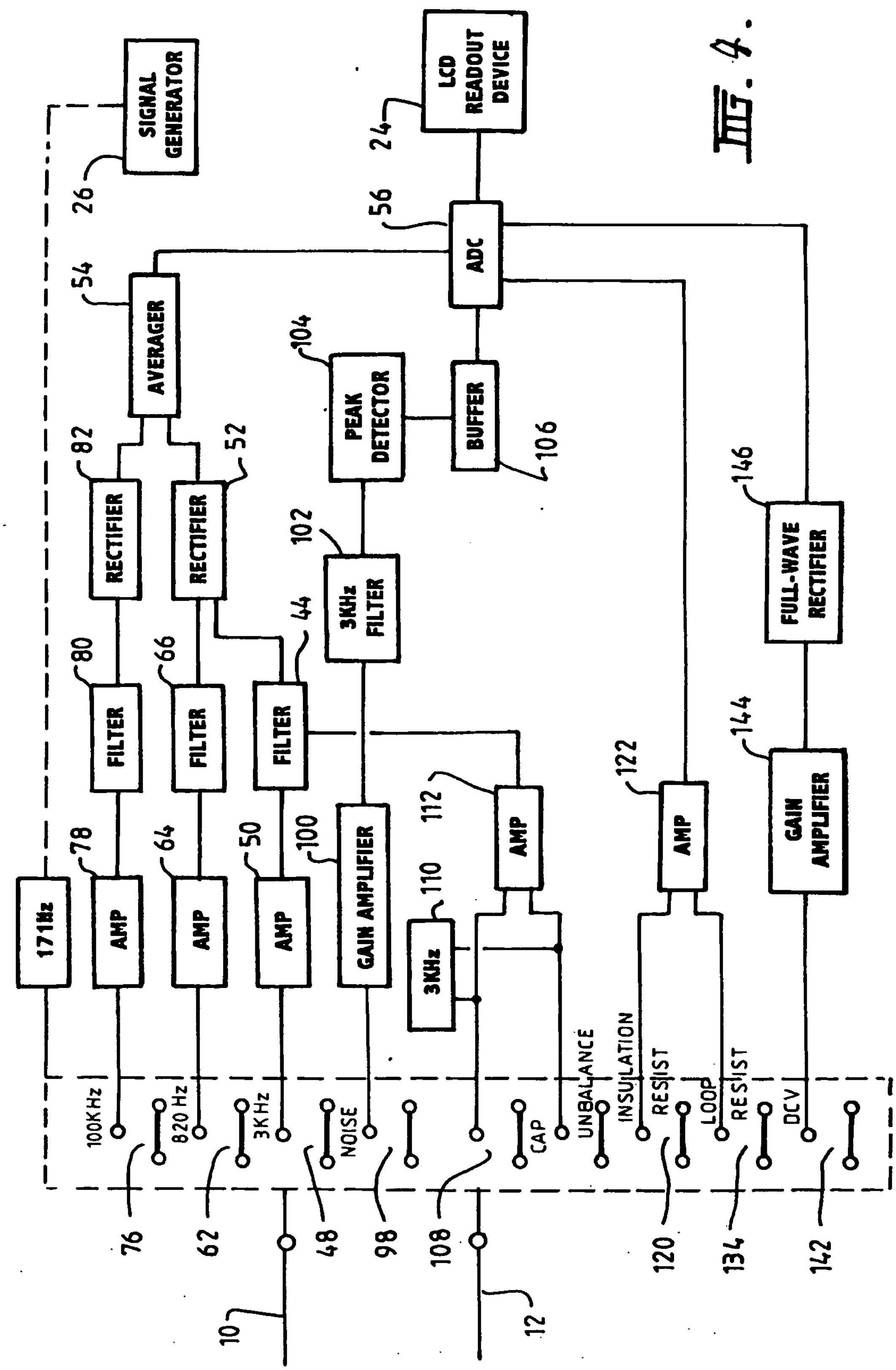
SIGNAL GENERATOR
LCD READOUT DEVICE
ADC
AVERAGER
RECTIFIER
RECTIFIER
PEAK DETECTOR
BUFFER
3KHz FILTER
FULL-WAVE RECTIFIER
FILTER
FILTER
FILTER
GAIN AMPLIFIER
AMP
AMP
AMP
171Hz
AMP
AMP
AMP
GAIN AMPLIFIER
3KHz
100KHz
820 Hz
3KHz
NOISE
CAP
UNBALANCE
INSULATION RESIST
LOOP RESIST
DCV
26
24
56
54
104
82
52
106
102
146
80
66
44
144
122
112
78
64
50
100
110
76
62
48
98
108
120
134
142
10
12

FIG. 4.

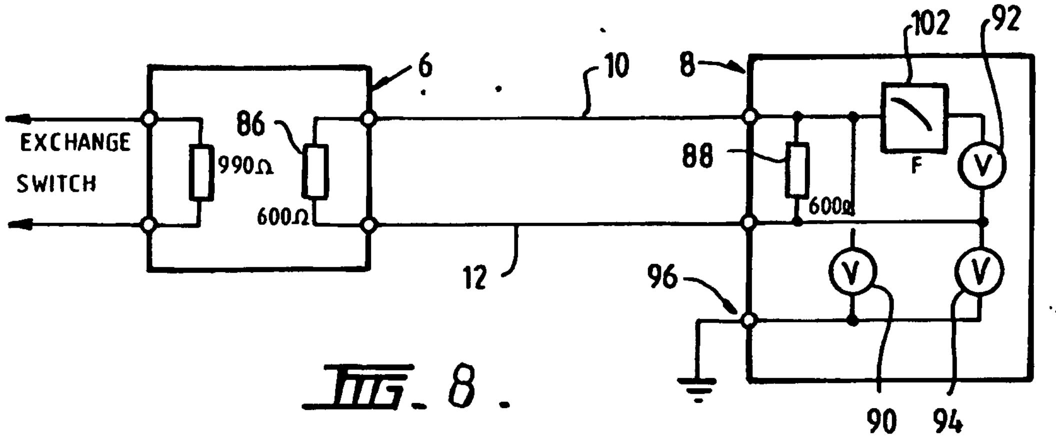

FIG. 8.

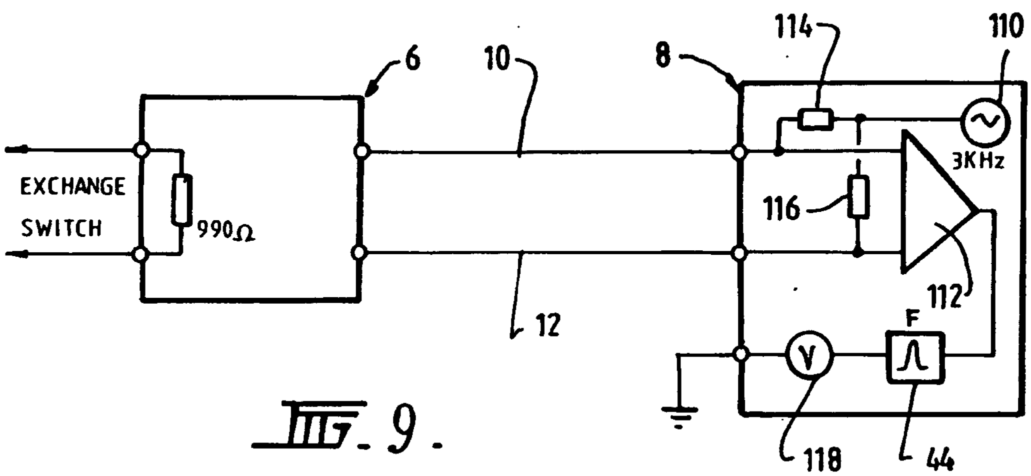

FIG. 9.

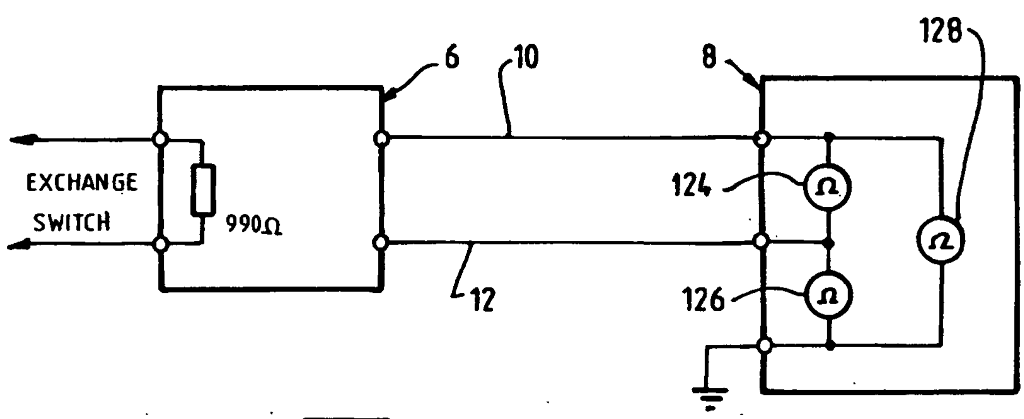

FIG. 10.

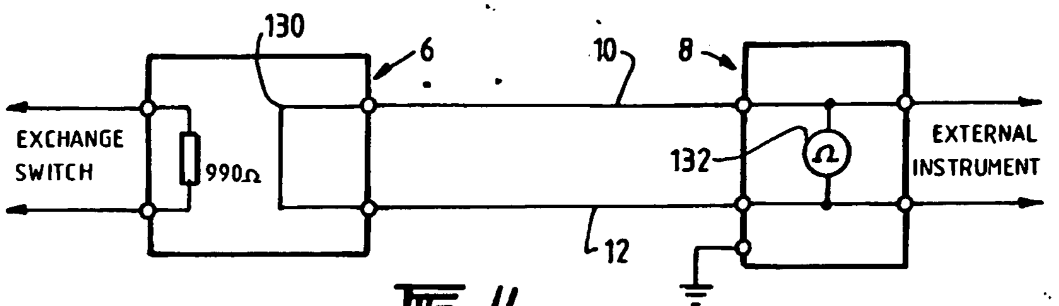

FIG. 11.

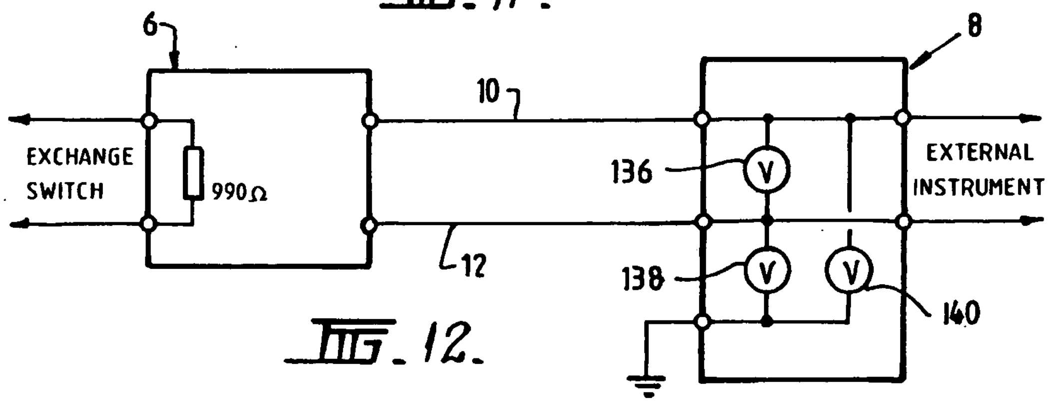

FIG. 12.

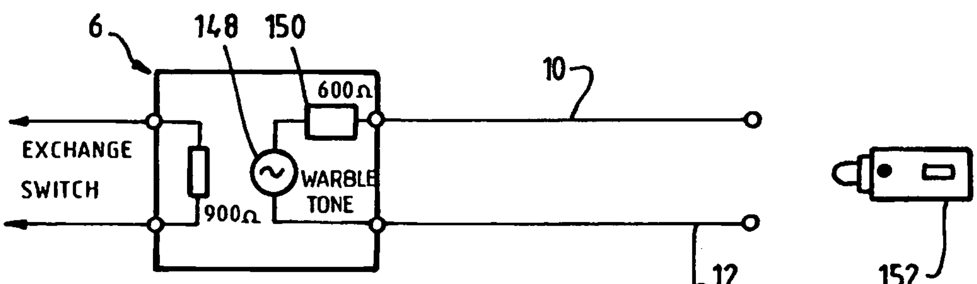

FIG. 13.

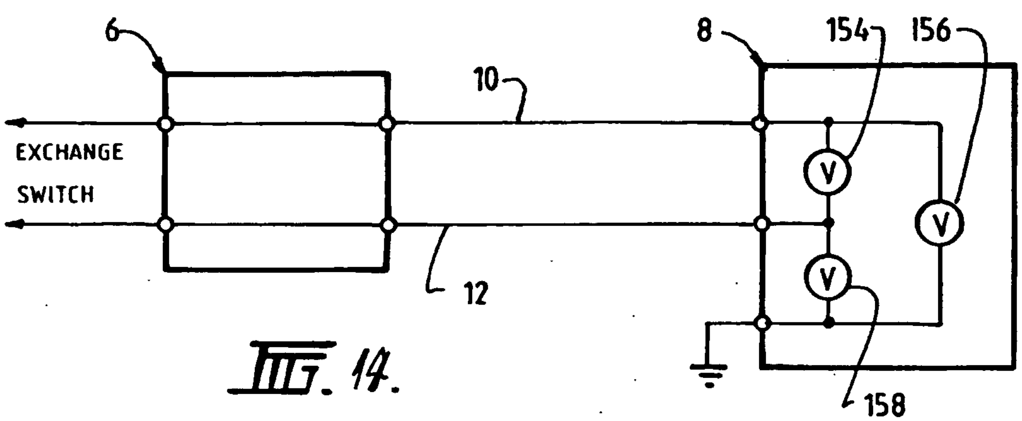

FIG. 14.